# CYGNO-04
# Status of material scrutiny work

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Collaboration mtg - 06/dez/2023

# Data available right now

- Anna Calanca masters' thesis (2022-2023)

CHARACTERIZATION OF PROTOTYPES OF A GASEOUS TPC WITH OPTICAL READOUT FOR THE CYGNO EXPERIMENT

- Some spreadsheets
  Anna + Giulia (simulation data)

Table 1

| piece # | description | weight [kg] | Ra228 from Th232 [Bq/kg] | Th228 from Th232 [Bq/kg] | Ra226 from U238 [Bq/kg] | Th234 from U238 [Bq/kg] | Pa2 from U23 [Bq/ |
|---|---|---|---|---|---|---|---|
| 1 | CMOS sensor | 0,0109 | 0,4770642 | 0,486238 | 0,623853 | 1,0091743 | 0,64 |
| 2 | sensor frame | 0,0232 | 4,8706896 | 4,784482 | 3,448275 | 12,5 | 6,03 |
| 3 | sensor frame holder | 0,068 | 0,1029411 | 0,235294 | 0,067647 | 7,3529411 | 3,82 |
| 4 | peltier cooler | 0,1862 | 0,0019334 | 0,001288 | 0,000912 | 0,0644683 | 0,11 |
| 5 | electronic board | 0,0412 | 5,0485436 | 4,902912 | 4,538834 | 3,8834951 | 6,06 |

- Matthias results (.txt files)

```
=====================================================================

sample:         camera HAMAMATSU, mod. C15550-20UP, S.No. 000141, CYGNUS
weight:         2.92568 kg
live time:      77278 s
detector:       GeMPI2

radionuclide concentrations:

Th-232:
Ra-228:         (0.8 +- 0.1) Bq/kg      <==>    (1.9 +- 0.2) E-7 g/g
Th-228:         (1.3 +- 0.7) Bq/kg      <==>    (3.3 +- 0.2) E-7 g/g

U-238:
Ra-226          (0.60 +- 0.06) Bq/kg    <==>    (4.9 +- 0.5) E-8 g/g
```

# Anna's thesis: measurements at LNF and STELLA facilities

- LNF: proved to be not enough accurate
- STELLA measurements (@ LNGS underground lab):
  - camera:

| Sample | Supplier | weight [g] | live time [s] | Ra-228 | Th-228 | Ra-226 | Pa-234m |
|---|---|---|---|---|---|---|---|
| ccd , mod. C11440-52U, board only | Hamamatsu | 225,5 | 1190529 | 1,03 ± 0,06 | 1,06 ± 0,06 | 1,15 ± 0,04 | 1,1 ± 0,2 |
| PRIME-BSI EXPRESS | Teledyne | 719,1 | 58484 | 1,3 ± 0,1 | 1,8 ± 0,1 | 1,00 ± 0,06 | 6 ± 2 |
| orca-flash4.0, model C11440-22CU | Hamamatsu | 4.08 | 83383 | 2,1 ± 0,2 | 2,1 ± 0,1 | 1,8 ± 0,1 | 7 ± 2 |
| cMOS | Thorlabs Quantalux | 264,6 | 644410 | 0,26 ± 0,02 | 0,63 ± 0,03 | 0,21 ± 0,01 | 3,0 ± 0,4 |

| Sample | Supplier | weight [g] | live time [s] | U-235 | K-40 | Cs-137 | Co-60 |
|---|---|---|---|---|---|---|---|
| ccd , mod. C11440-52U, board only | Hamamatsu | 225,5 | 1190529 | 0,06 ± 0,01 | 4,3 ± 0,4 | (7 ± 1)e-3 | <1,2 |
| PRIME-BSI EXPRESS | Teledyne | 719,1 | 58484 | 0,27 ± 0,06 | 3,6 ± 0,5 | <32 e-3 | <17e-3 |
| orca-flash4.0, model C11440-22CU | Hamamatsu | 4.08 | 83383 | 0,4 ± 0,1 | 1,9 ± 0,3 | 0,09 ± 0,03 | <0,012 |
| cMOS | Thorlabs Quantalux | 264,6 | 644410 | 0,12 ± 0,01 | 1,2 ± 0,1 | <0,0023 | <0,0055 |

  - copper shielding:

| Sample | Sample weight [g] | live time [s] | Ra-228 | Th-228 | Ra-226 | Th-234 | Pa-234m | U-235 |
|---|---|---|---|---|---|---|---|---|
| Copper frame | 649 | 1751947 | <0,35 | <0,43 | <0,42 | <67 | <25 | <0,51 |
| two pieces with pins of two copper frames | 12,54 | 844883 | 0,23 ± 0,05 | 0,27 ± 0,05 | 0,23 ± 0,05 | ±0,90 | <6,5 | <56 e-3 |

| Sample | Sample weight [g] | live time [s] | K-40 | Cs-137 | Co-60 | Co-58 | Mn-54 | Pb 210 |
|---|---|---|---|---|---|---|---|---|
| Copper frame | 649 | 1751947 | <1,9 | <0,15 | <0,18 | 0,3 ± 0,1 | <0,14 | – |
| two pieces with pins of two copper frames | 12,54 | 844883 | 1,8 ± 0,5 | <19 e-3 | <52 e-3 | <25 e-3 | <23 e-3 | 75 ± 8 |

# Anna's spreadsheet: additional data from other parts / materials

- Camera: broken-down list

| piece # | description | weight [kg] | Ra228 from Th232 [Bq/kg] | Th228 from Th232 [Bq/kg] | Ra226 from U238 [Bq/kg] | Th234 from U238 [Bq/kg] | Pa234m from U238 [Bq/kg] | K40 [Bq/kg] | U235 [Bq/kg] | Cs 137 [Bq/kg] |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CMOS sensor | 0,0109 | 0,4770642 | 0,486238 | 0,623853 | 1,0091743 | 0,6422018 | 321,100917 | 0,0834862 | 0,0385321100 |
| 2 | sensor frame | 0,0232 | 4,8706896 | 4,784482 | 3,448275 | 12,5 | 6,034482 | 3,44827586 | 0,2586206 | 0,0370689655 |
| 3 | sensor frame holder | 0,068 | 0,1029411 | 0,235294 | 0,067647 | 7,3529411 | 3,8235294 | 1,17647058 | 0,2205882 | 0,0147058823 |
| 4 | peltier cooler | 0,1862 | 0,0019334 | 0,001288 | 0,000912 | 0,0644468 | 0,1127819 | 0,01396348 | 0,0010741 | 0,0002900107 |
| 5 | electronic board | 0,0412 | 5,0485436 | 4,902912 | 4,538834 | 3,8834951 | 6,067961 | 5,82524271 | 0,2184466 | 0,0485436893 |

- GEMs

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 22 | | in m2 | mBq/pc | | | | | | | |
| 23 | GEM foil | 0,048 | 0,19 | 0,096 | 0,2 | 1 | 5 | 2,2 | 0,097 | 0,05 |
| 24 | | | Bq/m2 | | | | | | | |
| 25 | | 48 | 0,0039583 | 0,002 | 0,004166 | 0,0208333 | 0,1041666 | 0,04583333 | 0,0020208 | 0,0010416666 |

- Lens / Window

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 27 | old camera objective | 0,2135 | 0,3606557 | 0,365339 | 1,920374 | | 4,2154566 | 51,5222482 | 0,1451990 | 0,0463700234 |
| 28 | Suprasil | 0,220 | 0,0011 | 0,0013 | 0,00066 | 0,013 | 0,028 | 0,0015 | 0,00045 | 0,0054 |

# Giulia's spreadsheet: additional data from other parts / materials

- GEMs

N1 | fx

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | GEM | Reference | Limit/Meas | Activity (Bq/kg) | mass (kg) | Ngen | t_eq (year) | Activity (mBq/p | piece mass (kg | Comments | CYGNO mass (I | Activity ( microBq/cm^2) | tot surf (cm^2) |
| 2 | U238 (Th234) | Laubenstein @LNGS | M | 1.63E-01 | 0.7 | 1.00E+06 | 2.79E-01 | 1 | 0.00615 | | 1.62 | 1.95E+00 | 512 |
| 3 | U238 (Ra226) | Laubenstein @LNGS | M | 3.25E-02 | 0.7 | 1.00E+06 | 1.39E+00 | 0.2 | 0.00615 | | | 3.91E-01 | 512 |
| 4 | U235 | Laubenstein @LNGS | L | 1.58E-02 | 0.7 | 1.00E+06 | 2.87E+00 | 0.097 | 0.00615 | | | 1.89E-01 | 512 |
| 5 | Th232 (Ra228) | Laubenstein @LNGS | L | 3.09E-02 | 0.7 | 1.00E+06 | 1.47E+00 | 0.19 | 0.00615 | | | 3.71E-01 | 512 |
| 6 | Th232 (Th228) | Laubenstein @LNGS | L | 1.56E-02 | 0.7 | 1.00E+06 | 2.90E+00 | 0.096 | 0.00615 | | | 1.88E-01 | 512 |
| 7 | K40 | Laubenstein @LNGS | L | 3.58E-01 | 0.7 | 1.00E+07 | 1.27E+00 | 2.2 | 0.00615 | | | 4.30E+00 | 512 |
| 8 | Cs137 | Laubenstein @LNGS | L | 8.13E-03 | 0.7 | 1.00E+07 | 5.57E+01 | 0.05 | 0.00615 | | | 9.77E-02 | 512 |
| 9 | Co60 | Laubenstein @LNGS | L | 7.48E-03 | 0.7 | 1.00E+07 | 6.06E+01 | 0.046 | 0.00615 | | | 8.98E-02 | 512 |
| 10 | | | | | | | | | | | | | |
| 11 | GEM | Reference | Limit/Meas | Activity (Bq/kg) | mass (kg) | Ngen | t_eq (year) | | | | | Activity ( microBq/cm^2) | tot surf (cm^2) |
| 12 | U238 | TREX https://link.sp | L | 1.32E-02 | 0.008025 | 1.00E+06 | 2.98E+02 | | | | | 1.70E-01 | 625 |
| 13 | Th232 | TREX https://link.sp | M | 5.45E-03 | 0.008025 | 1.00E+06 | 7.25E+02 | | | | | 7.00E-02 | 625 |
| 14 | U235 | TREX https://link.sp | M | 2.80E-02 | 0.008025 | 1.00E+06 | 1.41E+02 | | | | | 3.60E-01 | 625 |
| 15 | K40 | TREX https://link.sp | M | 6.31E-02 | 0.008025 | 1.00E+07 | 6.26E+02 | | | | | 8.10E-01 | 625 |
| 16 | Co60 | TREX https://link.sp | L | 2.34E-03 | 0.008025 | 1.00E+07 | 1.69E+04 | | | | | 3.00E-02 | 625 |
| 17 | Cs137 | TREX https://link.sp | L | 1.56E-03 | 0.008025 | 1.00E+07 | 2.54E+04 | | | | | 2.00E-02 | 625 |
| 18 | | | | | | | | | | | | | |

also suggested by Cristina - thanks!

**Background assessment for the TREX dark matter experiment**

J. Castel[1,2], S. Cebrián[1,2,a], I. Coarasa[1,2], T. Dafni[1,2], J. Galán[1,2,3], F. J. Iguaz[1,2,4], I. G. Irastorza[1,2], G. H. Mirallas[1,2], A. Ortiz de Solórzano[1,2], E. Ruiz-Chóliz[1,2]

Eur. Phys. J. C (2019) 79:782
https://doi.org/10.1140/epjc/s10052-019-7282-6

# Giulia's spreadsheet: additional data from other parts / material

Hamamatsu, orca-flash4.0,

| Camera Body | Reference | Limit/Meas | Activity (Bq/kg) | mass (kg) | Ngen | t_eq (year) | Activity (Bq/pc) | piece mass (kg) |
|---|---|---|---|---|---|---|---|---|
| U238 (Th234) | Laubenstein @LNGS | M | 3.16E+00 | 3.98E+01 | 3.00E+07 | 7.55E-03 | 7 | 2.21275 |
| U238 (Ra226) | Laubenstein @LNGS | M | 8.13E-01 | 3.98E+01 | 3.00E+07 | 2.94E-02 | 1.8 | 2.21275 |
| U235 | Laubenstein @LNGS | M | 1.81E-01 | 3.98E+01 | 3.00E+07 | 1.32E-01 | 0.4 | 2.21275 |
| Th232 (Ra228) | Laubenstein @LNGS | M | 9.49E-01 | 3.98E+01 | 3.00E+07 | 2.52E-02 | 2.1 | 2.21275 |
| Th232 (Th228) | Laubenstein @LNGS | M | 9.49E-01 | 3.98E+01 | 3.00E+07 | 2.52E-02 | 2.1 | 2.21275 |
| K40 | Laubenstein @LNGS | M | 8.59E-01 | 3.98E+01 | 3.00E+07 | 2.78E-02 | 1.9 | 2.21275 |
| Cs137 | Laubenstein @LNGS | M | 4.07E-02 | 3.98E+01 | 3.00E+07 | 5.87E-01 | 0.09 | 2.21275 |
| Co60 | Laubenstein @LNGS | L | 5.42E-03 | 3.98E+01 | 3.00E+07 | 4.40E+00 | 0.012 | 2.21275 |

useful for future simulations

| Camera Lens (glass) | Reference | Limit/Meas | Activity (Bq/kg) |
|---|---|---|---|
| U238 (Th234) | Laubenstein @LNGS | M | 4.22E+00 |
| U238 (Ra226) | Laubenstein @LNGS | M | 1.92E+00 |
| U235 | Laubenstein @LNGS | M | 1.45E-01 |
| Th232 (Ra228) | Laubenstein @LNGS | M | 3.61E-01 |
| Th232 (Th228) | Laubenstein @LNGS | M | 3.65E-01 |
| K40 | Laubenstein @LNGS | M | 5.15E+01 |
| Cs137 | Laubenstein @LNGS | L | 2.67E-02 |
| Co60 | Laubenstein @LNGS | L | 4.64E-02 |
| La138 | Laubenstein @LNGS | M | 2.44E+00 |

| Camera Lens (fused | Reference |
|---|---|
| U | Haereus Suprasil: http |
| Th | Haereus Suprasil: http |
| K | Haereus Suprasil: http |

| Acrylic | Reference | Limit/Meas | Activity (Bq/kg) |
|---|---|---|---|
| U238 (Ra226) | Laubenstein @LNGS | L | 3.50E-03 |
| Th232 (Ra228) | Laubenstein @LNGS | L | 5.00E-03 |
| Th232 (Th228) | Laubenstein @LNGS | L | 4.50E-03 |
| K40 | Laubenstein @LNGS | L | 3.50E-02 |

| Acrylic | Reference | Limit/Meas | Activity (Bq/kg) |
|---|---|---|---|
| U | SNO: https://www.radi | L | 2.96E-04 |
| Th | SNO: https://www.radi | L | 5.69E-05 |
| K | SNO: https://www.radi | L | 7.12E-05 |

# STELLA: some more additional data

- PMTs:  not in the spreadsheet!

```
================================================================================

sample:          n. 8 PMT Hamamatsu, type: R7378A, CYGNUS
weight:          135.3 g (total)
live time:       488867 s
detector:        GePV

radionuclide concentrations:
```

- To be done: double check STELLA data x Spreadsheet
  - consistency of different records
  - checksum camera parts x  camera total

- Ongoing measurements: flexible PCB sheet
  - Delivered to Matthias on 25/oct/2023

- PMMA : perhaps we already have (D. Pinci is checking) ✓

# What do we need? : action items list

- To update and consolidate: ≠ spreadsheets + Stella results
- To check: the consistency between current info ←→ DESIGN
- To list: missing parts / materials
  - Help from designers

- To build: a Data Base (SQL)
  - Spreadsheet (prototype) → DB

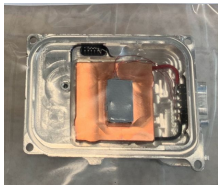
    A comprehensive DB is useful to assess the BKG contributions at any level

    - Monte Carlo: BKG studies, sensitivity calculations, data validation
    - Data Analysis: systematics evaluation, cuts, etc..

# What do we need?  proposal : additional DB fields

- A comprehensive DB is useful to assess the BKG contributions at any level
  - BKG breaking down:
    1. single parts

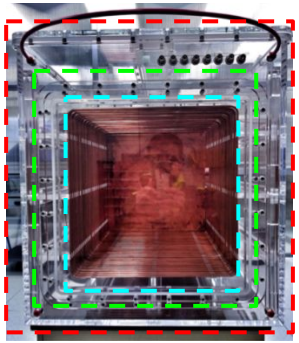
$$X_i$$

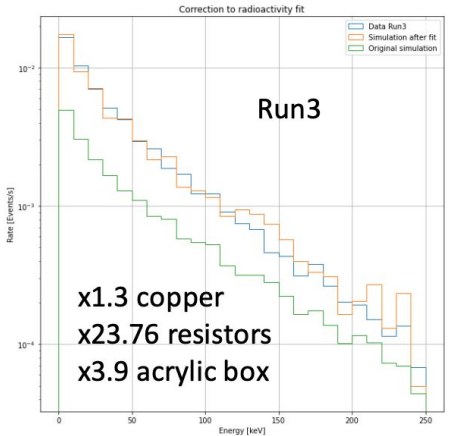
, , . . .

    2. subsystems

$$X_{ij}$$




$$\sum_{i,j} X_{ij}$$



# What do we need? : proposal

- A comprehensive DB is useful to assess the BKG contributions at any level
  - BKG breaking down: 1. single parts; 2. subsystems… &

3. position → CYGNO-XX modular design